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KEY FACTORS THAT INFLUENCE NETWORK CAPACITY AND ARCHITECTURE: FEEDBACK, DUALITY AND SOURCE-CHANNEL SEPARATION

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14. ABSTRACT

This project understands the fundamental limits of networks from three important perspectives: feedback, duality and source channel separation. Using each of these three key factors, we develop a theory of network architecture from a cross layer perspective: Feedback can help enhance performance and enable control, duality can help transform one architecture to another and source-channel separation can help develop low complexity algorithms.

15. SUBJECT TERMS

Feedback, Duality, Source Channel Separation

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Sriram Vishwanath
UU	UU	UU	UU		19b. TELEPHONE NUMBER 512-471-1190

Report Title

KEY FACTORS THAT INFLUENCE NETWORK CAPACITY AND ARCHITECTURE: FEEDBACK, DUALITY AND SOURCE-CHANNEL SEPARATION

ABSTRACT

This project understands the fundamental limits of networks from three important perspectives: feedback, duality and source channel separation. Using each of these three key factors, we develop a theory of network architecture from a cross layer perspective: Feedback can help enhance performance and enable control, duality can help transform one architecture to another and source-channel separation can help develop low complexity algorithms.

List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

R. Soundararajan and S. Vishwanath, “Hybrid Coding for Gaussian Broadcast Channels with Gaussian Sources”, accepted to the IEEE Transactions on Information Theory, available at http://arxiv.org/pdf/0906.2603.

J. Jose and S. Vishwanath, "Sum Capacity of Degraded Gaussian Interference Networks," submitted to IEEE Transactions on Information Theory, Sep 2010.

C. Lo, R. W. Heath, Jr., and S. Vishwanath, "Opportunistic Relay Selection with Limited Feedback", IEEE Transactions on Vehicular Technology, 2010.

Number of Papers published in peer-reviewed journals: 3.00

(b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

Number of Papers published in non peer-reviewed journals: 0.00

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

Peer-Reviewed Conference Proceeding publications (other than abstracts):

C. Lo, R. W. Heath, Jr., and S. Vishwanath, "Opportunistic Relay Selection with Limited Feedback", IEEE Vehicular Technology Conference (VTC), 2008.

J. Jose and S. Vishwanath, "Sum Capacity of Degraded Gaussian Interference Networks," IEEE Information Theory Workshop (ITW), 2010

R. Soundararajan and S. Vishwanath, “Communicating the Difference of Correlated Gaussian Sources Over a MAC”, Data Compression Conference (DCC), 2009.

R. Soundararajan and S. Vishwanath, “Hybrid Coding for Gaussian Broadcast Channels with Gaussian Sources”, IEEE International Symposium on Information Theory (ISIT), 2010.

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts): 4

(d) Manuscripts

Number of Manuscripts: 0.00

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED
Rajiv Soundararajan	0.40
Jubin Jose	0.40
Caleb Lo	0.20
FTE Equivalent:	**1.00**
Total Number:	**3**

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Sriram Vishwanath	0.06	No
FTE Equivalent:	**0.06**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
Christopher Slaughter	0.05
FTE Equivalent:	**0.05**
Total Number:	**1**

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	1.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:.....	1.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:.....	1.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):	1.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:	1.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Caleb Lo
Total Number: 1

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

See attachment

Technology Transfer

Final Report
Contract: W911NF-07-1-0465

KEY FACTORS THAT INFLUENCE NETWORK CAPACITY AND ARCHITECTURE: FEEDBACK, DUALITY AND SOURCE-CHANNEL SEPARATION

PI: Sriram Vishwanath

This project's goal was to understand the limits and architectural constraints of networks based on three essential ingredients: feedback, duality and source channel separation. Over the past three years, each aspect has been investigated by the PI and his research team in detail. The rest of this document details the accomplishments.

The first outcome of this effort is in the domain of source-channel separation. Source channel separation is one of the core components in network architecture today. However, it is well known that, in multiterminal systems, such an architecture can be significantly suboptimal.

To demonstrate examples that would build an understanding of the question: to separate or not to separate, the PI and his team have analyzed two different communication systems and found regimes where one scheme is better than the other.

The first paper [1] considers the problem of transmitting the difference of two jointly Gaussian sources over a two-user additive Gaussian noise multiple access channel (MAC). The goal is to recover this difference within an average mean squared error distortion criterion. Each transmitter has access to only one of the two Gaussian sources and is limited by an average power constraint. In this work, a lattice coding scheme that achieves a distortion within a constant of a distortion lower bound is presented if the signal to noise ratio (SNR) is greater than a threshold. Further, uncoded transmission is shown to be worse in performance to lattice coding methods.

The second paper [2] considers a degraded Gaussian broadcast channel over which Gaussian sources are to be communicated. When the sources are independent, this paper shows that hybrid coding achieves the optimal distortion region, the same as that of separate source and channel coding. It also shows that uncoded transmission is not optimal for this setting. For correlated sources, the paper shows that a hybrid coding strategy has a better distortion region than separate source-channel coding below a certain signal to noise ratio threshold. Thus, hybrid coding is a good choice for Gaussian broadcast channels with correlated Gaussian sources

[1] R. Soundararajan and S. Vishwanath, "Communicating the Difference of Correlated Gaussian Sources Over a MAC", http://arxiv.org/pdf/0812.1091

[2] R. Soundararajan and S. Vishwanath, "Hybrid Coding for Gaussian Broadcast Channels with Gaussian Sources", http://arxiv.org/pdf/0906.2603.

The second outcome of this effort is in the domain of duality in networks. In this case, our goal was to uncover symmetries in networks, and show that a considerable number of such symmetries exist. These symmetries become particularly useful when transforming coding strategies and other protocols from one problem setting to another.

The main setting we studied in this case is degraded Gaussian interference networks. In our work in [3], we find the capacity of degraded K-user Gaussian interference networks, and then show the symmetry of the channel by demonstrating that the capacity remains the same for the transposed channel as well. We do this using a new outer bounding technique for this channel, and by showing that a superposition based achievable strategy meets the outer bound.

[3] J. Jose and S. Vishwanath, "Sum Capacity of Degraded Gaussian Interference Networks," submitted to IEEE Transactions on Information Theory, Sep 2010.

The final outcome is in the domain of feedback. Feedback is an essential feature of networks. Whether it be physical layer feedback, or feedback at the higher layers such as TCP acks, feedback is an essential component of reliable communication systems. In our work, we have studied the cross layer implications of feedback in wireless networks. In our work [3], we show that TCP, routing, scheduling and physical layer rate allocation can be viewed jointly as optimization problems in the presence of (limited) feedback. In fact, with a few bits of feedback, we can control resource allocation, access, route selection and perform rate control to increase network reliability tremendously.

[4] C. Lo, R. W. Heath, Jr., and S. Vishwanath, "Opportunistic Relay Selection with Limited Feedback", IEEE Transactions on Vehicular Technology, to appear.